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EXECUTIVE SUMMARY

LOW LEVEL RADIOACTIVE INCINERABLE WASTE CHARACTERIZATION

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The characterization of low level radioactive incinerable waste, the present production rate of which is about 5000 m^3 per year, was completed as part of the systematic comprehensive reactor waste characterization research program being undertaken to provide data to NMMD for the development of waste management strategies and processing options. Because of the heterogeneity of the waste 1115 individual bags, amounting to about 67 m^3 waste in total, were examined to derive representative physical and radiochemical composition data.

The average composition of incinerable waste was established as; paper 40%, plastic 39%, rubber 5%, cotton 9%, and other materials 7%. Total combustible material in the waste is approximately 97% as about half of the "other materials" classification was wood. Slightly more than 5% of the waste volume consisted of halogenated materials such as PVC and Neoprene.

Generally the activity level of this waste was low, the contact dose rate of 87% of the bags was below 10 uSv (1mr)/h, 11% were less than 100 uSv (10 mr)/h, and only one bag approached the acceptance limit of 600 uSv (60 mr)/h. The gross gamma activity of the waste averaged 13MBq (350 uCi) per cubic metre which would produce an incinerator ash activity of 760 MBq (20.5 mCi) per cubic metre. As the bulk of the activity is due to radionuclides having half lives of less than one year, the activity in the ash will decay to 160 MBq (4.3 mCi)/m^3 within a decade of production. At that time the radionuclides of concern will be Co-60 and Cs-137.

P.S.

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32-295-462	837.812	February 1, 1988	88-22-K

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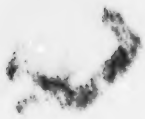

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LOW LEVEL RADIOACTIVE INCINERABLE WASTE CHARACTERIZATION

A.S. Williamson

The physical and radiochemical composition of low level radioactive incinerable waste was determined as part of the systematic radioactive waste characterization research underway to provide data to NMMD to assist in waste management strategy development. Some 67 m^3 waste was examined to establish representative composition and radionuclide inventories. Approximately 97% by volume of the waste was combustible and just over 5% consisted of halogenated materials. The typical activity level for the waste was established at 13 MBq (350 uCi)/m^3. The bulk of the activity is due to radionuclides with half lives less than one year, therefore a decade after incineration the only radionuclides of concern in the ash will be Co-60 and Cs-137.

The Chemical Research Department has been characterizing reactor operating wastes in respect of physical and chemical composition, activity levels, radionuclide inventories, etc since 1982 to provide data used by Nuclear Materials Management Department to develop waste management strategies and define waste treatment equipment requirements. The characterization of incinerable reactor waste was undertaken as one part of this program to provide information for the definition of future incinerator and off-gas treatment needs.

Operation of Ontario Hydro's nuclear generating stations produces approximately 6000 m^3 of solid reactor waste per year at present before processing and it is predicted this could rise to about 8000 m^3 per year by 1993/1/. About 60% of the total solid waste arisings received at the Radioactive Waste Operations Site (RWOS) are classified as incinerable and are burnt in the Waste Volume Reduction Facility (WVRF) radioactive waste

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incinerator. Not all potentially combustible waste is incinerated; packages having a contact dose rate greater than 600 uSv/h (60 mr/h) and those containing more than a token amount of halogenated plastics are compacted.

Characterization:

1115 individual bags of incinerable waste resulting from normal maintenance operations at PNGS and BNGS over a period of several months were examined to derive the average physical and chemical composition of the waste. The examination procedure involved weighing each bag and visually inspecting the bag to determine the composition of the contents by volume of the major material classifications. The contact dose rate of each waste bag was measured. Bags having a contact dose rate greater than 30 uSv/h (3 mr/h) were gamma scanned to determine their beta/gamma radionuclide inventory and randomly selected bags were analysed for carbon-14 and tritium.

Bags selected for gamma scanning were rotated on a turntable and scanned with a germanium detector from a distance of 1 m for 3000 seconds. The detector efficiency was calibrated for the different radionuclides using a dummy bag of average composition to which a known source containing a typical radionuclide mix had been added.

Those bags on which tritium and carbon-14 determinations were made were eluted at the Research Division using the technique developed for the characterization of compactible waste/2/.

The physical and chemical composition of this waste varies considerably from bag to bag and a wide range of different materials were found, not all of which were combustible. The heterogeneous nature of the waste is illustrated by the partial listing of bag compositions given in Appendix 1. The complete characterization data is contained in two data bases in the Nuclear Materials Research Unit and can be provided on request to anyone interested/5/.

A summary of the waste composition distribution by bags is presented in Table 1.

Table 1

Waste Composition Distribution

% Content (Volume)	Number of Bags				
	Paper	Plastic	Rubber	Cotton	Other
0	281	336	695	623	835
10	121	116	319	324	155
25	103	74	60	59	46
50	209	194	31	63	32
75	113	118	3	17	4
100	288	277	7	29	43

Analysis of the waste composition data suggests that an average composition of incinerable waste would be as shown in Table 2.

Table 2

Average Composition of Incinerable Waste

Material	%
Paper	40
Plastic	39
Rubber	5
Cotton	9
Other	7

The 39% plastic content was made up of 33% polyethylene, 4% polyvinyl chloride and 2% other plastics such as Tygon and polycarbonate. The rubber consisted of natural rubber and Neoprene gloves and overshoes. The "other" class of materials consisted of items such as glass bottles, metal pieces, wood and insulation.

The activity level of the waste was determined by measuring the contact dose rate of each bag examined. The low-level nature of incinerable waste was confirmed by these measurements which showed that 87% of the bags were less than 10 uSv/h (1 mr/h), 11% were less than 100 uSv/h (10 mr/h), and only one bag approached the acceptance limit of 600 uSv/h (60 mr/h).

The beta/gamma radionuclide inventory listed in Table 3 for the incinerable waste was derived from the actual gamma scans of those bags over 30 uSv/h (3 mr/h) plus a value for those bags with a contact dose rate of 10 uSv/h (1 mr/h) or less of: Co-60 400 kBq (11 uCi), Cs-137 30 kBq (0.8 uCi), Cs-134 6 kBq (0.16 uCi), Ce 144 31 kBq (0.84 uCi) per bag. These data were derived from gamma scans of two bags at this dose rate.

Table 3

Radionuclide Inventory of Incinerable Waste
(Total Volume of 67 m^3)

Radionuclide	Activity (MBq)	(uCi)	Average Percent Contribution
Cr-51	5.1	(139)	1
Mn-54	3	(80)	<1
Fe-59	6.1	(166)	1
Co-60	490	(13254)	58
Zr-95	63	(1697)	7
Nb-95	101	(2716)	12
Ru-103	2.3	(63)	<1
Ru-106	9.8	(266)	1
Sb-124	2	(55)	<1
Sb-125	23	(619)	3
Cs-134	15.6	(422)	2
Cs-137	72	(1941)	8
Ce-141	3.5	(94)	<1
Ce-144	53.4	(1444)	6
	849.8	(22956)	

The above calculated total radionuclide inventory for the 1115 bags represents an equivalent gross gamma activity of 13 MBq/m^3 (350 uCi/m^3) waste or alternatively 760 MBq/m^3 (20.5mCi/m^3) incinerator ash. These levels were derived using the following extrapolations: 250 bags of waste are equivalent to a volume of 15 m^3 which in turn yields 0.25 m^3 ash/1/.

Randomly selected bags were analysed for tritium and carbon-14 which were found in all cases although the quantities varied widely from bag to bag. Due to this scatter good statistical analysis of the data could not be made, however, possible concentrations of these radionuclides per cubic metre of waste could range between 4-70 GBq (108 mCi-1.9 Ci) for tritium and 37-120 kBq (1-3.25 uCi) for carbon-14. In comparison the values derived for tritium and carbon-14 in the earlier compactible waste characterisation study were 300-400 GBq (8-11 Ci) and 37-185 kBq (1-5 uCi) respectively/2/. Mean values for tritium and carbon-14 in incinerable waste from the PNGS retubing operation were; tritium, 4 GBq/m^3 (113 mCi/m^3) and carbon-14, 185 MBq/m^3 (5 mCi/m^3)/3/.

Discussion:

Incinerable waste has an extremely heterogeneous composition which can vary widely from bag to bag as illustrated by the waste composition distribution by bags summary of Table 1. However, when considered on a scale of several cubic metres of waste, the average composition shown in Table 2 appears reasonable. This indicates that approximately 97% by volume of the waste consisted of combustible materials as about half of the "other" classification was wood. Slightly more than 5% by volume consisted of halogenated materials (PVC and Neoprene).

The 1115 bags examined represented about 67 m^3 waste and this volume contained some 204 kg PVC material which could contain about 68 kg PVC resin. A complete incinerator charge of 15 m^3 waste could thus contain about 15 kg PVC resin which could generate in the order of 15 m^3 HCl gas at the 500°C operating temperature during the burn. This is small when dilution by the typical stack emissions of 3600 m^3/h during incinerator operation is taken into consideration.

The generally low contact dose rate of incinerable waste bags along with the maximum dose limitation per bag of 600 uSv/h (60 mr/h) results in a low gross gamma activity for the waste feed of 13 MBq/m^3 (350 uCi/m^3). Even with the concentrating effect of incineration, the ash activity will only be about 760 MBq/m^3 (20.5 mCi/m^3). The radionuclide inventory data given in Table 3 shows that the bulk of the activity is contributed by radionuclides having half-lives of one year or less and a decade after production the only radionuclides of concern in the ash will be Co-60 and Cs-137. At this time the activity of the ash will have decayed to 160 MBq/m^3 (4.3 mCi/m^3) made up of 110 MBq (3 mCi) Co-60 and 50 MBq (1.3 mCi) Cs-137.

Comparison of the calculated possible ash radionuclide inventory derived in this study with the actual measurements made in the 1983 radioactive incinerator ash characterization showed reasonably good agreement between the two sets of data indicating that the radionuclide content of incinerable waste has remained substantially consistent with time/4/. Using the calculated ash density of 730kg/m^3 determined in the 1983 study to convert the data to common units, an average initial ash activity of 950 MBq/m^3 (25.5 mCi/m^3) is obtained versus the 760 MBq/m^3 (20.5 mCi/m^3) calculated in this work.

With a decade of radioactive decay factored into the calculation, the ratios for Co-60 and Cs-137 inventories between the ash and incinerable waste characterizations are 0.4 and 1.2 respectively which again is a reasonably good correlation considering the inhomogeneity of the incinerable waste and the fact that the ash analysed was from incineration of different batches of waste.

It is expected that the bulk of the tritium and carbon-14 found in the waste will be exhausted to atmosphere in the overall stack emissions.

CONCLUSIONS:

1. Although there is wide variation in the contents of individual bags of incinerable waste, the bulk composition is similar to that found for compactable waste being composed of about 40% each of paper and plastic, the remaining 20% consisting of rubber, cotton, and miscellaneous materials in approximately equal quantities. About 97% of the waste was classified as combustible. Slightly more than 5% by volume of halogenated materials is likely to be present in any charge.

2. The average volume of halogenated materials in a waste charge to the incinerator could contain approximately 15 kg PVC resin which would yield some 15 m^3 HCl gas at the normal operating temperature. This should be taken into account if consideration is given to the incineration of Freon dry cleaning residues which also contain chlorine.

3. Even with the concentrating effect of incineration the generally low activity level of incinerable waste, typically about 13 MBq(350 uCi)/m^3, suggests the final ash activity will be in the order of 760 MBq/m^3 (20.5 mCi/m^3). Because radionuclides contributing the major part of the activity have half-lives of less than one year, the radionuclides of concern in the ash a decade after production will be Co-60 and Cs-137, and the activity level will have decreased to about 160 MBq/m^3 (4.3 mCi/m^3).

4. The possible ash radionuclide inventory calculated from the levels found in the raw incinerable waste showed reasonably good agreement with the data derived in the 1983 incinerator ash characterization study indicating the radioactivity of this waste has remained consistent with time.

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2. Williamson, A.S., Ontario Hydro Research Division Report 85-58-K.

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5. Incinerable waste characterization data bases: "ENABLE" file: - INCINWST.DBF, "LOTUS2" file: - IWC.WK1.

Appendix 1

Incinerable Waste Characterisation

Bag No	Mass (kg)	CDR (mR/h)	Paper	Plastic	Rubber	Cotton	Other
			(% by volume)				
1	2.2	1.0	50	50	0	0	0
2	1.0	1.0	90	0	0	10	0
3	3.0	1.0	0	100	0	0	0
4	3.0	1.0	30	30	0	40	0
5	4.2	1.0	5	85	0	10	0
6	4.5	1.0	0	100	0	0	0
7	4.5	1.0	45	0	35	15	5
8	2.2	1.0	90	0	0	0	10
9	5.0	1.0	5	95	0	0	0
10	2.5	1.0	10	90	0	0	0
11	3.8	1.0	0	90	10	0	0
12	5.5	1.0	10	90	0	0	0
13	3.1	1.0	5	95	0	0	0
14	2.2	1.0	60	30	0	10	0
15	2.0	1.0	55	0	30	15	0
16	4.0	1.0	75	0	10	10	5
17	6.5	15.0	60	20	10	10	0
18	3.5	1.0	50	40	5	5	0
19	2.2	2.0	70	0	30	0	0
20	5.4	1.0	5	95	0	0	0
21	4.3	1.0	0	100	0	0	0
22	0.5	1.0	50	50	0	0	0
23	3.4	1.0	5	95	0	0	0
24	2.5	1.0	0	95	0	5	0
25	2.7	1.0	0	100	0	0	0
26	9.0	1.0	10	55	0	5	30
27	3.2	1.0	80	0	20	0	0
28	1.3	1.0	20	20	0	60	0
29	1.2	1.0	0	95	3	0	2
30	4.2	1.0	5	90	0	5	0
31	5.3	1.0	3	95	0	2	0
32	3.5	1.0	0	90	10	0	0
33	2.5	1.0	0	95	5	0	0
34	3.2	1.0	10	80	10	0	0
35	6.6	1.0	5	90	5	0	0
36	2.8	1.0	0	95	0	5	0
37	3.2	1.0	10	20	30	40	0
38	1.5	1.0	0	0	0	100	0
39	3.5	1.0	5	95	0	0	0
40	2.0	1.0	45	25	15	0	15
41	1.7	1.0	100	0	0	0	0

Appendix 1 (contd)

Bag No	Mass (kg)	CDR (mR/h)	Paper	Plastic	Rubber	Cotton	Other
			(	% by volume			)
42	9.0	1.0	10	90	0	0	0
43	3.4	1.0	10	0	0	90	0
44	12.6	1.0	0	0	30	0	70
45	3.7	1.0	15	0	5	60	20
46	3.5	2.0	100	0	0	0	0
47	3.0	1.0	90	0	0	10	0
48	6.5	2.0	0	100	0	0	0
49	5.0	1.0	60	40	0	0	0
50	4.3	1.0	0	75	0	25	0
51	0.5	1.0	5	90	0	0	5
52	9.5	3.0	5	40	30	5	20
53	9.3	1.0	20	0	0	0	80
54	2.0	1.0	80	20	0	0	0
55	5.2	1.0	0	95	5	0	0
56	2.8	1.0	15	80	0	5	0
57	2.0	10.0	0	95	0	5	0
58	9.1	1.0	0	85	15	0	0
59	3.5	1.0	50	50	0	0	0
60	4.1	1.0	70	30	0	0	0
61	5.5	1.0	80	0	10	10	0
62	4.6	1.0	30	60	5	5	0
63	1.5	1.0	90	5	0	5	0
64	4.9	1.0	0	90	5	5	0
65	4.3	1.0	70	30	0	0	0
66	2.8	1.0	10	70	10	5	5
67	1.6	1.0	95	5	0	0	0
68	3.6	1.0	100	0	0	0	0
69	6.5	1.0	85	10	5	0	0
70	1.5	1.0	100	0	0	0	0
71	0.5	1.0	100	0	0	0	0
72	5.2	1.0	90	10	0	0	0
73	2.8	1.0	85	5	5	5	0
74	9.9	15.0	15	80	0	0	5
75	4.0	1.0	45	50	5	0	0
76	2.3	1.0	40	10	20	30	0
77	0.5	1.0	0	90	10	0	0
78	6.7	1.0	0	80	15	5	0
79	3.0	1.0	100	0	0	0	0
80	1.9	1.0	91	5	2	0	2
81	3.2	1.0	30	70	0	0	0
82	40.0	2.0	0	100	0	0	0
83	5.4	1.0	55	30	5	0	10
84	4.9	1.0	0	90	10	0	0

Appendix 1 (contd)

Bag No	Mass (kg)	CDR (mR/h)	Paper	Plastic	Rubber	Cotton	Other
			(% by volume)				
85	2.8	3.0	95	5	0	0	0
86	2.0	1.0	10	60	20	10	0
87	3.2	1.0	0	80	0	0	20
88	1.2	1.0	80	0	2	5	13
89	11.5	1.0	0	100	0	0	0
90	3.2	1.0	50	0	25	25	0
91	5.5	70.0	100	0	0	0	0
92	4.5	1.0	0	80	2	18	0
93	12.0	0.0	0	100	0	0	0
94	4.5	1.0	65	20	10	5	0
95	9.3	1.0	20	50	0	0	30
96	2.4	1.0	85	0	5	5	5
97	5.3	1.0	40	20	20	10	10
98	2.0	1.0	0	70	20	0	10
99	8.1	1.0	20	0	0	80	0
100	2.5	1.0	100	0	0	0	0
101	3.1	1.0	20	50	5	0	25
102	2.4	1.0	40	50	0	0	10
103	1.6	1.0	85	0	5	10	0
104	3.9	1.0	10	0	0	90	0
105	7.0	1.0	69	0	20	10	1
106	3.5	1.0	30	50	10	10	0
107	3.4	1.0	50	30	0	5	15
108	4.8	2.0	75	0	10	10	5
109	8.4	3.0	45	10	35	10	0
110	4.0	1.0	70	25	0	5	0
111	3.2	1.0	20	55	0	0	25
112	2.5	1.0	90	0	0	10	0
113	6.8	3.0	80	0	5	10	5
114	4.0	1.0	75	25	0	0	0
115	2.0	1.0	30	45	0	10	15
116	1.7	1.0	60	20	5	10	5
117	2.7	1.0	75	15	0	10	0
118	2.2	1.0	50	50	0	0	0
119	3.6	1.0	5	40	0	45	10
120	5.1	1.0	10	40	0	50	0
121	5.0	1.0	35	60	0	0	5
122	3.0	1.0	55	20	5	5	15
123	4.7	1.0	75	0	0	25	0
124	2.5	1.0	90	0	0	10	0
125	2.0	1.0	85	5	0	10	0
126	1.8	1.0	63	20	5	10	2
127	3.5	1.0	48	0	20	30	2

Appendix 2

Typical Radionuclide Inventory

in Incinerable Waste Bags

Bag No	Co60	Zr95	Nb95	Sb125	Cs137	Ce144
	(		uCi/bag			)
17	27	0	26	22	31	6
52	14	2	4	0	0	0
57	5	53	95	0	13	137
91	259	8	19	34	14	26
139	93	6	13	550	0	0
262	4	0	1	0	7	0
268	8	0	19	0	3	6
276	4	0	1	0	3	2
303	18	0	0	0	0	0
312	37	0	0	0	2	0
331	240	0	0	0	1	0
341	18	0	0	0	0	0
360	32	0	0	0	2	1
402	1	9	0	0	0	0
409	11	0	0	0	5	0
438	96	0	0	0	0	0
471	1	0	0	0	0	3
482	19	0	0	0	0	0
485	27	0	0	9	4	7
496	16	0	0	0	2	0
498	2	2	3	1	0	5
499	2	2	3	1	0	5
515	1	8	18	0	343	5
555	13	81	178	0	0	0
569	120	0	0	0	8	7
574	82	0	6	0	562	0
605	124	1	0	0	23	1
653	5	60	0	0	0	8
685	29	1006	1638	0	0	244
689	5	15	29	0	0	3
716	12	415	613	0	0	54
783	9	6	10	0	28	5
789	7	15	29	2	11	11
810	138	7	7	0	9	8
819	3	1	4	0	6	4